PHYSICAL AND CHEMICAL PROPERTIES OF MAJOR IMPERIAL VALLEY SOILS

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INTRODUCTION

Knowledge of the soil's chemical and physical properties is required to interpret the crop production potential and to evaluate engineering and conservation practices. Although soil survey reports of observable physical characteristics of soil provide valuable information, interrelated physical and chemical measurements at standardized locations provide useful scales of reference in the establishment of soil management practices, such as tillage, irrigation, drainage, salt balance, and fertilization.

The alluvial soils of the Imperial Valley of California are composed of highly stratified Colorado River deposits, largely from mixed sedimentary rock material transported from the Grand Canyon area of Arizona. The variations in the soils are due mostly to textural differences caused by the manner and sequence in which the alluvial material was deposited. The deposits vary considerably in texture; both vertically and horizontally. Cropping and soil management practices for the approximately 500,000 acres of irrigated land within the Valley, in general, are affected and influenced predominantly by these soil textural characteristics. Since most of the variation within soil types appears to be due to texture, and since management practices vary due to textural differences, an evaluation was made of the relationships between soil texture as measured by particle size distribution and factors such as soil moisture retention, infiltration rate, hydraulic conductivity, surface area, and other physical and chemical characteristics.

1/ Contribution of the Agricultural Research Service (ARS) and the Soil Conservation Service (SCS), U.S. Department of Agriculture, in cooperation with the Illinois Agricultural Experiment Station.

2/ Soil scientist, ARS, and assistant professor of soil physics, Department of Agronomy, University of Illinois, Urbana, Ill.; soil scientist, ARS, Brawley, Calif.; and soil scientist, El Centro Work Unit, SCS, El Centro, Calif., respectively.

EXPERIMENTAL METHODS

Approximately 80 percent of the cultivated area in Imperial Valley can be classified within six phases representing four soil series as follows:

1. Imperial series (clays and silty or sandy clays more than 40 inches deep).
   a. Imperial silty clay.
2. Holtville series (fine textures -- clay to clay loam, overlying contrasting coarser textures at depths of 20 to 36 inches).
   a. Holtville silty clay (silty clay over loams to sandy loams).
   b. Holtville silty clay, sandy substratum (silty clay over loamy fine sands to fine sands).
3. Indio series (silt loams, loams, and very fine sandy loams more than 40 inches deep).
   a. Indio loam.
   b. Indio very fine sandy loam, sandy substratum (very fine sandy loam over loamy fine sands to fine sands).
4. Meloland series (medium or coarse textures -- loams to fine sands, overlying contrasting fine textures -- clays to clay loams, at depth of 16 to 35 inches).
   a. Meloland very fine sandy loam.

Sites for the six soil profiles were selected (fig. 1), and at each site a pit was dug. The soil profile description was recorded, and soil samples were taken for chemical and physical analysis. Bulk soil samples (300 pounds or 30 gallons) were taken from each significant layer as determined from the soil profile description.

PHYSICAL METHODS

The field soil samples were crushed and passed through a 2-mm sieve. Subsamples were taken from each layer and sent to the U.S. Salinity Laboratory, Riverside, Calif., where the fraction percentages of specific clay types were identified (7).[3] Particle-size distribution by pipette analysis (6) was measured by the Soil Survey Laboratory, SCS, Riverside, Calif. Additional subsamples from each site were sent to the California Division of Highways Laboratory, San Diego, Calif., where measurements of Atterburg constants (2) and maximum compaction density at optimum moisture were made.

3/ Underscored numbers in parentheses refer to Literature Cited, p. 18.

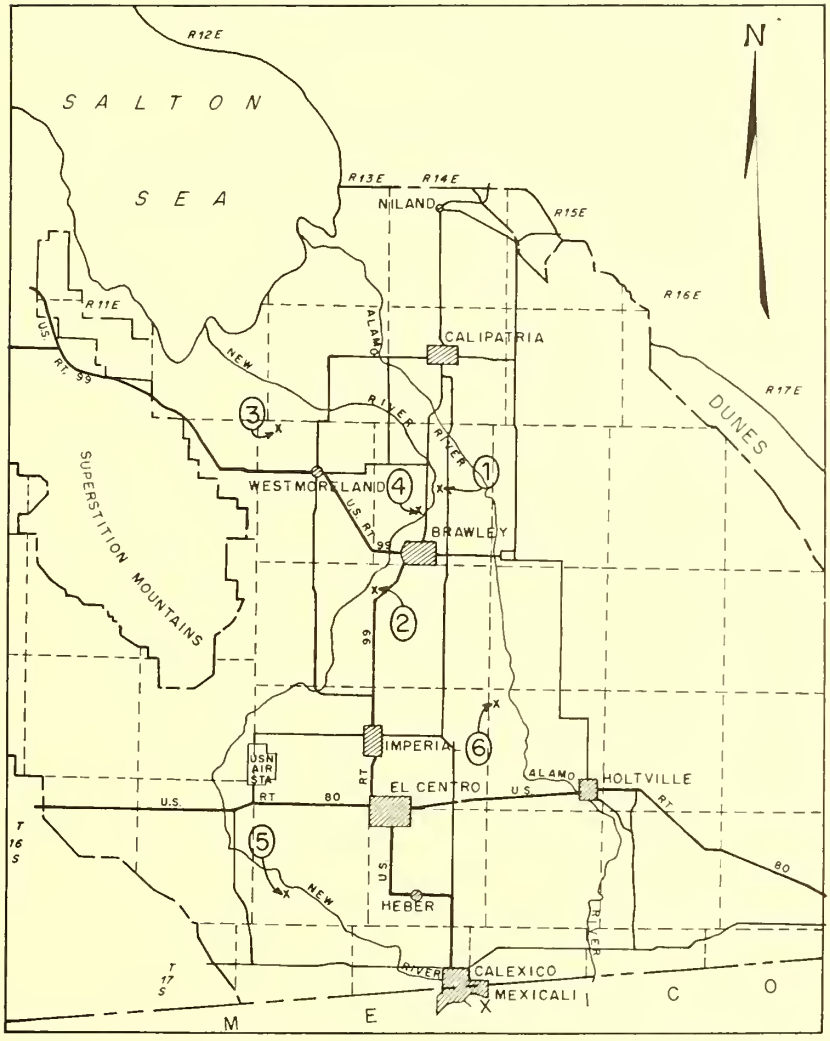

Figure 1 -- Location of sampling sites in Imperial Valley, Calif.

A Kelly core sampler (5) was used to obtain samples (four replications) for determining bulk densities for each soil layer at a specified depth. The average infiltration rate was determined at each site by use of six infiltrometer tubes (4), 12 inches in diameter by 24 inches in height.

Soil moisture retention curves on crushed sieved samples were obtained by means of pressure-plate apparatus (10) for suctions of 1 bar or less, and pressure-membrane apparatus (9) was used for suctions greater than 1 bar.

CHEMICAL METHODS

Soil salinity, soluble anions and cations, soil reaction (pH), cation exchange capacity and exchangeable cations, sodium adsorption ratios, and other determinations were made in accordance to procedures described in USDA Agricultural Handbook 60. Organic matter was determined by the method described by Aguilera and Jackson (1). Organic nitrogen was determined by the Kjeldahl method (3). Total phosphorus and the various phosphorus fractions were determined by methods outlined in "Methods of Soil Analysis" (8).

RESULTS

Soil Series

The soils in this study were all classified as Alluvial Soils in the 1938 USDA Yearbook, "Soils and Men". Before the new system of soil classification (about 1959), the soils studied here best fitted the Regosol concept of Azonal Soils. They are classified as Torriorthents and Torrifluvents (11).

Parent materials of the soils studied here are unweathered lacustrine sediments, largely from mixed sedimentary rock material transported by the Colorado River. The silts and fine sands of these sediments may have been reworked by wind. In the desert climate of the study area, these soils are well drained, but drainage phases under irrigated agriculture are the usual situation. The general slope of these soils on the old lake bed is nearly flat except along certain fault lines where vertical displacement has occurred. Locally, there is a dune microrelief in areas where sands and silts have been moved by wind.

These soils differ from each other and from associated soil series only in texture and stratification. Significant differences in texture of the control section (10 to 40 inches in depth) or significant strata of contrasting texture within the section are criteria for separation at family or series level.

The soils studied are used principally for irrigated agriculture and dominate mapping units that cover approximately 80 percent of the nearly 500,000-acre irrigated area of Imperial Valley. Of this 80 percent, Imperial silty clay comprises about 40 percent, Holtville mapping units about 20 percent, Meloland mapping units about 12 percent, and Indio mapping units about 8 percent.

Physiography

The soils of the study area all lie within the beach line of ancient Lake Cahuilla. Within this area on the lake plain, there are no consistent relationships between soils and surface features.

Climate

The climate of the Imperial Valley is hot and dry east of the Peninsula Coast Range of mountains in the low basin of the Colorado Desert and shut off from the moderating effects of the ocean. The rainfall is very low, because the region depends on the westerly winds from the Pacific Ocean for its supply of rain. These winds, in crossing the coastal mountain range, precipitate their moisture on the western slopes. They pass over the low desert basin (in general below sea level) as hot, arid winds.

The Imperial Valley (at El Centro) has an average annual rainfall of only 2.72 inches. Throughout the year, the relative humidity is fairly high for a desert region; the annual average being 30 percent. During July and August, the average relative humidity increases and does not decrease until sometime in September. In July and August, the prevailing winds change from westerly to southeasterly, which brings in moist air from the Gulf of California.

April and May are associated with the greatest wind velocities, and average 3.8 miles per hour daily. These climatic variations do not affect the normal distribution curve of evapotranspiration, because June, July, August, and September are essentially the same; the average being about one-third inch per day during this period. The climate is highly favorable for crops, an average of 314 days between frosts and 12 days of frost.

Description of Soil Series

Imperial Series

The soils of the Imperial series have a fine-textured control section, which usually contains less than 0.2-percent carbon, and is dry unless irrigated. These characteristics plus climatic setting and high shrink-swell ratio make it a Vertic Torriorthent. Imperial soils are in the fine, montmorillonitic (calcareous), hyperthermic family of the subgroup.

Holtville Series

The soils of the Holtville series have no diagnostic horizon. The control section contains strongly contrasting fine textures over loamy particle-size classes and is dry unless irrigated. The Holtville series is a member of a clayey over loamy, montmorillonitic (calcareous), hyperthermic family of Typic Torrifluvents. A taxadjunct of the Holtville series with a control section of fine over sandy particle-size classes is included in this study.

Meloland Series

The soils of the Meloland series have no diagnostic horizon. The control section contains strongly contrasting coarse loamy over fine particle-size classes and is dry unless irrigated. The Meloland series is a member of a coarse-loamy over clayey, mixed (calcareous), hyperthermic family of Typic Torrifluvents.

Indio Series

The soils of the Indio series have no diagnostic horizon. The coarse silty control section usually contains less than 0.2-percent carbon and is dry unless irrigated. The Indio series is a member of a coarse-silty, mixed (calcareous), hyperthermic family of Typic Torriorthents. A taxadjunct of the Indio series with a coarse silty over sandy control section is included in this study.

Soil Profile Descriptions

Profile 1:	Imperial Silty Clay
LOCATION:	Imperial County, Calif. Near center of NW1/4 N1/2 Tract 118, sec. 15, T 13 S., R. 14 E., San Bernardino Base Meridian. Approximately 1,170 feet west, 1,000 feet south of gate 116-AA, Best Lateral 1. From East Main Street, Brawley, 3 1/2 miles north along Best Canal, west 0.2 miles on Best Lateral 1 to Gate 116-AA.
CLASSIFICATION:	Vertic Torriorthent, fine montmorillonitic (calcareous) hyperthermic family.
VEGETATION:	Cultivated, fallow after sugar beets.
CLIMATE:	Annual average precipitation, 2.72 inches; average annual temperature, 72° F. Average frost-free growing season 314 days, January 29 to December 9.
PARENT MATERIAL:	Recent lacustrine sediments.
TOPOGRAPHY:	Lacustrine basin, nearly level, less than 1-percent slope to north.
ELEVATION:	150 feet below sea level.
DRAINAGE:	Runoff slow, permeability slow, well drained, water table not observed.
SOIL MOISTURE:	Dry in Ap, slightly moist below.
REMARKS:	pH determined by Truog color test. Very little variation of pH or effervescence. No coarse fragments. Platy structure noted, may be microstratification. Thick plates break with conchoidal fracture when dry. Minor strata of lighter texture are sometimes found at varying depths within the profile. Vertical cracks up to 1 inch wide and 6 feet deep, spaced about 1 foot apart, are sometimes filled with lighter textured materials.

Horizon	Depth Inches	Description
Ap	0-13	Pinkish-gray (7.5YR 6/2) silty clay, brown (7.5YR 5/4) moist; moderate coarse and very coarse subangular blocky; very hard, very firm, sticky and plastic; few very fine to coarse random exped roots; common very fine to fine discontinuous random pores; moderately alkaline (pH 8.1); strongly effervescent; few fine white gypsum efflorescences; clear smooth boundary.
C1	13-60	Light-brown (7.5YR 6/4) silty clay, brown (10YR 4/3) moist; weak medium to very coarse platy; very hard, very firm, sticky and plastic; very few very fine exped roots; moderately alkaline (pH 8.1); strongly effervescent; discontinuous horizontal lenses of loamy fine sand up to 2 inches thick at 42-inch depth. Common fine white gypsum efflorescences to a depth of 36 inches. Horizon arbitrarily sampled for characterization at 13- to 28-inch and 28- to 42-inch depths.

Profile 2: Holtville Silty Clay, Over Medium Textures

LOCATION: Imperial County, Calif. Tract 109, sec. 7, T. 14 S., R. 14 E., San Bernardino Base Meridian, in the ARS Imperial Valley Conservation Research Center Farm at the middle of north end of plot F-2, approximately 35 feet south of field road.

CLASSIFICATION: Typic Torrifluvent, clayey over loamy, montmorillonitic (calcareous), hyperthermic family.

VEGETATION: Cultivated, fallow after barley.

CLIMATE: Average annual precipitation 2.72 inches; average annual temperature, 72° F. Average frost-free growing season 314 days, January 29 to December 9.

PARENT MATERIAL: Recent lacustrine sediments.

TOPOGRAPHY: Lacustrine basin, nearly level, less than 1-percent slope to north.

ELEVATION: 90 feet below sea level.

DRAINAGE: Runoff slow, permeability slow, well drained, water table not observed.

SOIL MOISTURE: Dry in Ap, slightly moist below.

REMARKS: pH determined by Troug color test. Very little variation of pH or effervescence. No coarse fragments. Platy structure noted may be micro-stratification.

Horizon	Depth Inches	Description
Ap	0-10	Pinkish-gray (7.5YR 6/2) silty clay, brown (7.5YR 4/2) moist; weak coarse subangular blocky and weak very coarse platy; very hard, very firm, sticky, and plastic; few fine and very fine random roots; mildly alkaline (pH 7.8); strongly effervescent; clear smooth boundary.
C1	10-22	Light-brown (7.5YR 6/4) silty clay, brown (7.5YR 4/2) moist; weak medium subangular blocky and weak very coarse platy; very hard, firm, sticky and plastic; few fine and very fine random roots; few discontinuous very fine pores; mildly alkaline (pH 7.8); strongly effervescent; vertical lenses of silt, few fine white gypsum efflorescences; abrupt smooth boundary.
C2	22-33	Light-brown (7.5 YR 6/4) silty clay, brown (7.5YR 4/4) moist; moderate coarse platy; very hard, friable, slightly sticky and plastic; few fine and very fine roots; mildly alkaline; strongly effervescent; horizontal silty partings; few fine and medium gypsum efflorescences in cracks; clear smooth boundary.
C3	33-50	Pink (7.5YR 7/4) loam matrix, yellowish brown moist, with light-brown (7.5YR 6/4) silty clay microstrata, brown (7.5YR 5/4) moist; massive; hard, friable, nonsticky and slightly plastic; very few very fine roots in vertical cracks; mildly alkaline; strongly effervescent; loam strata 1/2 to 1 inch thick interbedded with silty clay partings up to 1/4 inch thick; few fine distinct rusty stains; slight cross bedding; vertical cracks up to 1/2 inch thick filled with silty clay loam; clear smooth boundary.

C4	50-56	Pink (7.5YR 7/4) loamy very fine sand, light yellowish brown (10YR 6/4) moist; massive; slightly hard, very friable, nonsticky and slightly plastic; few very fine roots in vertical cracks; mildly alkaline (pH 7.8); strongly effervescent; microstrata crossbedded; clear wavy boundary.
C5	56-66	Very pale-brown (10YR 7/3) very fine sandy loam matrix, light yellowish brown (10YR 6/4) moist; with pale-brown (10YR 6/3), very fine sandy loam horizontal microstrata, brown (10YR 4/3) moist; massive; slightly hard, friable, nonsticky and slightly plastic; very few very fine roots in vertical cracks; mildly alkaline (pH 7.8); strongly effervescent; slightly crossbedded microstrata with matrix layers 1/8 inch thick separated by 1/16 inch thick minor strata.

Profile 3: Holtville Silty Clay Taxadjunct, Coarse-Textured Substrata

LOCATION: Imperial County, Calif. Near center E1/2 SW1/4 Tract 130, sec. 6, T. 13 S., R. 13 S., R. 13 E., San Bernardino Base Meridian, approximately 250 feet west, 700 feet north of gate 179, Trifolium Lateral 9, 2 1/4 miles north of U.S. Highway 99 along Trifolium Lateral 9.

CLASSIFICATION: Typic Torrifluvent, clayey over sandy, montmorillonitic (calcareous), hyperthermic family.

VEGETATION: Fallow after cotton.

CLIMATE: Average annual precipitation, 2.72 inches; mean annual temperature, 72° F. Average frost-free growing season 314 days, January 29 to December 9.

PARENT MATERIAL: Recent lacustrine sediments.

TOPOGRAPHY: Lacustrine basin, nearly level, less than 1-percent slope to the north.

ELEVATION: 190 feet below sea level.

DRAINAGE: Slow runoff, permeability is slow over moderately rapid. Well drained.

SOIL MOISTURE: Moist.

REMARKS: Truog color test used to determine pH. Vertical cracks approximately 2 inches wide filled with loamy fine sand in the fine-textured horizons. Few minor strata of fine-textured material in coarse-textured substrata.

Horizon	Depth Inches	Description
Ap	0-17	Light-brown (7.5YR 6/4) silty clay, yellowish brown (10YR 5/4) moist; massive and weak, medium subangular blocky; very hard, very firm, sticky and very plastic; common very fine and few fine random roots; few very fine random tubular pores; moderately alkaline (pH 8.0); strongly effervescent; clear smooth boundary.
C1	17-24	Light-brown (7.5YR 6/4) silty clay, brown (7.5YR 5/4) moist; moderate, medium platy; very hard, firm, very sticky and very plastic; few fine random roots; common very fine random tubular pores; moderately alkaline (pH 8.0); strongly effervescent; clear smooth boundary.
C2	24-35	Very pale-brown (10YR 7/3) loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine random roots; many very fine random tubular pores; moderately alkaline (pH 8.0); strongly effervescent; abrupt smooth lower boundary.
C3	35-72	Very pale-brown (10YR 7/3) loamy fine sand, brown (10YR 5/3) moist; single grain; weakly coherent, very friable, nonsticky and non-plastic; very few fine random tubular pores; moderately alkaline (pH 8.0); strongly effervescent.

Profile 4: Meloland Loam

LOCATION: Imperial County, Calif. Near center of north side of NE1/4 NE1/4 Tract 93, sec. 16, T. 13 S., R. 14 E., San Bernardino Base Meridian. Approximately 175 feet south, 1,150 feet east of bridge over Spruce 3 drain on Highway 111.

CLASSIFICATION: Typic Torrifluvent, coarse loamy over clayey, mixed (calcareous), hyperthermic family.

VEGETATION: Fallow after cotton.

CLIMATE: Average annual precipitation, 2.72 inches; average annual temperature, 72° F. Average frost-free growing season 314 days, January 29 to December 9.

PARENT MATERIAL: Recent lacustrine sediments.

TOPOGRAPHY: Lacustrine basin, nearly level, less than 1-percent slope to north.

ELEVATION: 150 feet below sea level.

DRAINAGE: Well drained.

SOIL MOISTURE: Slightly moist.

REMARKS: pH determined by Truog color test. Very little variation pH or effervescence. No coarse fragments. Platy structure noted may be microstratification. Thin strata of lighter texture found within the fine textured substrata in some places.

Horizon	Depth Inches	Description
Ap	0-12	Light-brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable, slightly sticky and plastic; few medium and coarse roots, many fine and very fine random roots; mildly alkaline (pH 7.8); violently effervescent; abrupt smooth boundary.
C1	12-18	Very pale-brown (10YR 7/3) loamy fine sand, brown (10YR 5/3) moist; massive and single grain; weakly coherent, very friable, nonsticky and slightly plastic; few fine to very fine horizontal roots; mildly alkaline (pH 7.8); violently effervescent; microstrata crossbedded; abrupt wavy boundary.
C2	18-26	Very pale-brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; massive; hard, friable, slightly sticky and plastic; few fine and very fine random roots; common fine and very fine tubular pores with rusty linings; mildly alkaline (pH 7.8); violently effervescent; intermittent horizontal lenses of very fine sandy loam up to 2 inches thick at 19 inches, intermittent horizontal lenses of silty clay up to 2 inches thick at 23 inches; abrupt wavy boundary.

C3	26-38	Pink (7.5YR 7/4) clay, brown (7.5YR 5/4) moist; moderate very fine platy structure; very hard, firm, very sticky and very plastic; few very fine vertical and horizontal roots; few very fine tubular vertical pores; mildly alkaline (ph 7.8); strongly effervescent; few fine white gypsum efflorescences; thin vertical cracks spaced about 1 foot apart filled with loamy very fine sand; gradual smooth boundary.
C4	38-53	Pink (7.5YR 7/4) clay, brown (7.5YR 4/4) moist; massive; very hard, very firm, very sticky and very plastic; few fine roots in vertical cracks and irregular fractures; mildly alkaline (pH 7.8); strongly effervescent; many large white gypsum efflorescences in vertical cracks and irregular fractures; diffuse smooth boundary.
C5	53-71	Pink (7.5YR 7/4) clay, brown (7.5YR 4/4) moist; massive; very hard, firm, very sticky and very plastic; few very fine random roots; very few, very fine discontinuous tubular pores; mildly alkaline (pH 7.8); strongly effervescent with disseminated carbonates; many large white gypsum efflorescences in vertical cracks and irregular fractures to 59 inches, common medium rusty stains below 59 inches.

Profile 5: Indio Loam

LOCATION: Imperial County, Calif. Near the center of the NE 1/4 NE 1/4, sec. 29, T. 16 S., R. 13 E., San Bernardino Base Meridian, approximately 850 feet east, 400 feet north of gate 123, Wisteria Lateral 8. About 0.4 miles west of Wulf's Crossing and south of New River.

CLASSIFICATION: Typic Torriorthent, coarse-silty, mixed (calcareous) hyperthermic family.

VEGETATION: Cultivated, disked up after lettuce harvest.

CLIMATE: Average annual precipitation, 2.72 inches; average annual temperature, 72° F. Average frost-free growing season, 314 days, January 29 to December 9.

PARENT MATERIAL: Recent lacustrine sediments.

TOPOGRAPHY: Lacustrine basin, nearly level, less than 1-percent slope toward north.

ELEVATION: 25 feet below sea level.

DRAINAGE: Runoff slow, permeability moderately slow, well drained, water table not observed.

SOIL MOISTURE: Dry in Ap, slightly moist below.

REMARKS: pH determined by Truog color test. Very little variability of pH, or effervescence; no coarse fragments. Platy structure noted may be micro-stratification. Contrasting minor strata of coarser or finer textures may be at any depth. Vertical cracks 1/8 to 1/4 inch thick, 3 to 12 inches apart, up to 5 feet deep, filled with material from upper horizons. Crossbedding may be result of reworking by wind.

Horizon	Depth Inches	Description
Ap	0-12	Pinkish-gray (7.5YR 6/2) loam, dark gray-brown (10YR 4/2) moist; moderate medium subangular blocky; slightly sticky and slightly plastic; plentiful very fine random roots; few very fine pores; moderately alkaline (pH 8.2); strongly effervescent; abrupt wavy boundary.
C1	12-30	Very pale-brown (10YR 7/3) very fine sandy loam, brown (10YR 4/3) moist; massive and weak fine platy; slightly hard, very friable, nonsticky and nonplastic; few very fine random roots; very few very fine pores; moderately alkaline (pH 8.2); strongly effervescent; crossbedding in microstrata approximately 1 mm thick; few fine distinct rusty stains in cracks; gradual wavy boundary.
C2	30-44	Pink (7.5YR 7/4) loamy very fine sand, brown (10YR 5/3) moist; massive and weak fine platy structure; weakly coherent, very friable, nonsticky and nonplastic; few very fine random roots; very few very fine pores; moderately alkaline; strongly effervescent; crossbedded microstrata approximately 5 mm thick, few large strong brown (7.5YR 5/6) moist stains in cracks, diffuse wavy boundary.
C3	44-58	Pink (7.5YR 7/4) loamy very fine sand, brown (10YR 5/3) moist; massive and weak fine platy; soft, very friable, nonsticky and nonplastic; very few very fine vertical and horizontal roots; common very fine and fine continuous dendritic open pores with dark linings; moderately alkaline (pH 8.2); strongly effervescent; crossbedded microstrata about 5 mm thick; diffuse wavy boundary.

C4	58-72	Pink (7.5YR 7/4) loamy very fine sand, pale brown (10YR 6/3) moist; massive and weak fine platy structure; soft, very friable, nonsticky and nonplastic; very few very fine vertical and horizontal roots; few very fine to fine continuous dendritic pores; moderately alkaline; strongly effervescent; crossbedded microstrata about 5 mm thick.

Profile 6: Indio Very Fine Sandy Loam Taxadjunct, Deep Over Coarse Textures

LOCATION: Imperial County, Calif. Near the center of E1/2 lot 14, sec. 6, T. 15 S., R. 15 E., San Bernardino Base Meridian, approximately 530 feet west, 550 feet north of the headgate of Redwood Lateral 1. 4 1/2 miles north, 3/4 mile west of Meloland Experiment Station.

CLASSIFICATION: Typic Torriorthent, coarse-silty over sandy, mixed (calcareous) hyperthermic family.

VEGETATION: Barley stubble.

CLIMATE: Average annual precipitation, 2.72 inches; average annual temperature, 72° F. Average frost-free growing season, 314 days, January 29 to December 9.

PARENT MATERIAL: Recent lacustrine sediments.

TOPOGRAPHY: Lacustrine basin, nearly level, less than 1-percent slope toward north.

ELEVATION: 100 feet below sea level.

DRAINAGE: Runoff medium, permeability moderately slow, well drained, water table at 73 inches.

SOIL MOISTURE: Dry in Ap, noted below.

REMARKS: pH determined by Truog color test. Very little variability of pH or effervescence. Platy structure notes, may be microstratification. No coarse fragments. Crossbedding may be result of reworking by wind.

Horizon	Depth Inches	Description
Ap	0-13	Pink (7.5YR 7/4) very fine sandy loam, brown (7.5YR 5/4) moist; moderate medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common very fine and fine random roots and few medium vertical roots; common very fine and fine continuous random exped pores; moderately alkaline (pH 8.2); violently effervescent with disseminated carbonates; clear wavy boundary.
C1	13-27	Pink (7.5YR 7/4) very fine sandy loam, brown (7.5YR 5/4) moist; massive and weak coarse platy structure; slightly hard, very friable, nonsticky and slightly plastic; common very fine random roots; few fine horizontal roots; common very fine continuous random pores; moderately alkaline (pH 8.2); violently effervescent; few fine rusty stains in thin vertical and horizontal cracks; faint crossbedding; gradual wavy boundary.
C2	27-37	Pink (7.5YR 7/4) loam; brown (7.5YR 5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few very fine random roots; few very fine random pores; moderately alkaline (pH 8.2); violently effervescent; rusty stains in pores and fractures; abrupt smooth boundary.
C3	37-72	Very pale-brown (10YR 7/4) loamy fine sand, light brown (7.5YR 6/4); single grain; loose, nonsticky and nonplastic; moderately alkaline (pH 8.2); strongly effervescent; crossbedded to 42 inches, horizontal bedding below 42 inches, accumulation of soft black nodules 58 to 62 inches.

Physical Measurements

The clay fraction analyzed are presented in table 1 [4/] and confirm that clayey soils should be classified montmorillonitic as this clay type was predominant in all samples analysed. The particle-size distribution analysis is shown in table 2 for a wide range of sieve fractions. The Atterburg constants and the maximum compaction density at the optimum moisture content are presented in table 3. Table 4 shows the moisture retention data, and table 5 presents the average soil bulk density determinations. The average soil surface infiltration rates for the six soils are given in table 6.

4/ All tables are grouped together at the end of this report.

Chemical Measurements

The chemical analyses of soil salinity, soluble anions and cations, pH, exchange capacity, gypsum, calcium carbonate, free iron oxides, exchangeable sodium and potassium, sodium adsorption ratio, and other determinations are given in tables 7 and 8. The organic nitrogen, organic carbon, and organic matter analyses are shown in table 9. Table 10 presents the chemical analyses of total phosphorus and the various phosphorus fractions.

Relations Between Clay Content (<2μ) and Physical and Chemical Properties

To assist in comparing and interpreting the interrelationships of the physical and chemical properties of Imperial Valley soils, the data were entered into an IBM 360-75 computer, and various correlations and linear regression analyses were made. The results comparing clay content (<2μ) to various physical and chemical properties are given in table 11. Significant correlation coefficients were obtained for the relations between clay content and moisture retention (at all suctions), liquid limit, plastic index, saturation percentage, cation exchange capacity, gypsum content, free iron oxides, total surface area, organic matter, organic nitrogen, and total phosphorus.

Relations Between Saturation Percentage and Physical and Chemical Properties

Clay content (<2μ) was well correlated with many physical and chemical properties including the saturation percentage. Because of the ease in determining saturation percentage, an analysis of these relations to soil properties was made (table 12). The saturation percentage data gave the same levels of significance as obtained by the clay content. By using the linear relationships found between the easily determined saturation percentage and other more difficult to measure soil properties, the other more difficult to measure soil properties can be predicted or estimated.

Relations Between Sodium Adsorption Ratio and Some Selected Chemical Properties

The results of correlation analyses comparing sodium adsorption ratio (SAR) to exchangeable sodium percentage (ESP) and pH are given in table 13. No significant relation was found between SAR and ESP, but a significant correlation coefficient was obtained for the relation between SAR and pH. The relation between ESP and pH was not significant.

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Table 1 -- The fraction percentages of clay for each profile soil sample.

Soil[1/]	Depth	Fraction Percentage[2/]						
		Mt	Mi	Q+F	Chl	Verm	Am	Kaol
	Inches							
Imperial sic	0-13	39	28	19	7	1	2	0
Holtville sic	0-10	35	28	18	6	8	2	0
	50-66	46	30	14	9	0	2	1
Holtville sic Taxadjunct	0-17	40	28	18	7	0	2	0
	35-72	42	28	14	8	2	2	0
Meloland l	0-12	43	29	16	8	0	2	0
	18-26	45	29	14	8	2	2	0
	38-71	41	28	16	7	2	2	0
Indio l	0-12	40	30	17	7	0	2	0
Indio vfsl Taxadjunct	0-13	43	28	15	8	1	2	0
	37-72	44	28	15	8	3	2	0
Averages		42	29	16	8	2	2	1

1/ sic = silty clay
l = loam
vfsl = very fine sandy loam

2/ Mt = montmorillonite
Mi = mica
Q+F = quartz plus feldspars
Chl = chlorite
Verm = vermiculite
Am = amorphous minerals
Kaol = kaolinite

Table 2 -- Particle-size distribution analysis in percentages with size fraction in millimeters

Soil	Depth	Horizon	Very coarse sand (2-1)	Coarse sand (1-0.5)	Medium sand (0.5-0.25)	Fine sand (0.5-0.25)	Very fine sand (0.10-0.05)	Silt (0.05-0.002)	Clay (<0.002)	0.2-0.02	0.02-0.002	0.005-0.002	<0.001	<0.0002	Texture 1/ class
	Inches														
Imperial	0-13	Ap	0.1	0.1	0.1	1.0	5.1	42.3	51.3	13.0	35.1	18.4	48.1	17.9	sic
sic	13-28	C1	.0	.0	.0	.0	.4	55.7	43.9	5.5	50.6	18.8	37.9	13.7	sic
	28-42	C2	.0	.0	.0	.1	.6	52.4	46.9	5.1	48.0	18.6	39.1	15.1	sic
Holtville	0-10	Ap	.1	.2	.2	2.7	9.0	42.2	45.6	24.5	28.9	13.4	38.5	14.7	sic
sic	10-22	C1	.0	.0	.1	2.2	7.1	40.0	50.6	17.8	31.2	16.1	42.5	16.3	c
	33-50	C3	.0	.0	.1	.5	1.8	84.8	12.8	46.5	40.4	5.8	11.5	--	sil
	50-66+	C4 & C5	.0	.1	.1	.6	19.2	72.4	7.6	80.4	11.6	3.5	7.5	--	sil
Holtville	0-17	Ap	.1	.1	.2	4.5	7.1	43.0	45.0	18.1	35.6	14.7	39.1	15.9	sic
sic	17-24	C1	.0	.0	.0	2.2	1.9	43.1	52.8	6.6	40.4	19.4	41.5	--	sic
Taxadjunct	24-35	C2	.0	.0	.1	1.7	3.8	67.6	26.8	29.9	43.0	10.2	22.7	--	sicl
	35-72+	C3	.0	.1	.1	18.7	61.5	13.9	5.7	89.2	3.5	1.8	5.7	--	lvfs
Meloland l	0-12	Ap	.0	.1	.1	6.8	49.5	28.6	14.9	76.5	7.9	4.6	14.2	--	vfsl
	12-18	C1	.0	.1	.1	16.6	59.3	18.4	5.5	89.9	3.9	2.4	5.4	--	vfsl
	18-26	C2	.0	.1	.1	.5	9.1	75.2	15.0	57.9	26.8	5.9	13.8	--	sil
	26-38	C3	.1	.0	.0	.2	2.6	42.2	54.9	9.3	35.7	18.9	46.0	18.7	sic
	38-53	C4	.1	.0	.0	.1	1.6	46.2	52.0	8.4	39.5	19.5	43.3	18.1	sic
Indio l	0-12	Ap	.0	.7	4.0	22.6	7.3	47.2	18.2	47.6	20.2	6.5	16.4	--	l
	12-30	C1	.0	.1	.3	2.1	5.6	79.4	12.5	63.5	22.8	5.4	11.4	--	sil
	44-58	C3	.0	.1	.1	.5	29.7	62.7	6.7	84.9	7.8	3.4	6.5	--	sil
Indio	0-13	Ap	.0	.1	.1	3.7	32.6	49.9	16.6	68.4	14.4	5.5	14.5	--	l
vfsl	13-27	C1	.0	.0	.1	1.3	33.3	55.7	9.6	78.8	11.2	3.8	8.7	--	sil
Taxadjunct	27-37	C2	.0	.0	.1	1.3	12.9	73.6	12.1	65.6	22.0	5.0	11.0	--	sil
	37-62	C3	.0	.1	.4	50.3	35.6	9.8	3.8	86.9	2.2	1.1	3.8	--	fs

1/ sic=silty clay
c=clay
sil=silt loam
sicl=silty clay loam
lvfs=loamy very fine sand
vfsl=very fine sandy loam
l=loam
fs=fine sand

Table 3 -- Atterburg constants and maximum compaction density at optimum moisture for major soils of Imperial Valley

Soil [1/]	Depth	Atterberg constants: Liquid limit	Atterberg constants: Plastic limit	Atterberg constants: Plasticity index	Maximum compaction density at optimum moisture: Optimum moisture	Maximum compaction density at optimum moisture: Maximum density
	Inches	Percent	Percent	Number	Percent	Lb/ft^3
Imperial sic	0-13	58.0	22.7	35	16.0	112.0
	13-28	57.4	22.3	36	16.5	109.0
	28-42	58.3	23.0	35	16.0	111.0
Holtville sic	0-10	49.9	20.9	29	15.0	112.5
	10-22	58.0	21.4	37	10.0	110.0
	33-50	31.7	23.2	8	17.0	108.5
	50-66+	27.0	24.1	3	6.5	131.0
Holtville sic	0-17	53.7	21.4	32	13.5	116.5
Taxadjunct	17-24	59.9	21.8	38	15.0	114.0
	24-35	37.5	18.7	19	13.0	115.0
	35-72+	23.5	23.6	--	14.5	106.0
Meloland l	0-12	27.3	19.8	7	13.0	117.5
	12-18	24.5	24.3	--	15.0	108.0
	18-26	31.0	20.8	10	14.0	113.5
	26-38	65.8	21.7	44	15.5	110.0
	38-53	61.8	22.8	39	14.0	112.5
Indio l	0-12	27.6	20.6	7	10.0	121.5
	12-30	29.8	23.7	6	15.5	109.0
	44-58	28.9	22.2	7	14.0	112.5
Indio vfsl	0-13	28.5	19.7	9	14.0	117.0
Taxadjunct	13-27	26.0	21.6	4	15.0	114.0
	27-37	26.3	23.0	3	17.5	105.0
	37-62	23.5	23.4	--	6.0	105.5

1/ sic=silty clay
vfsl=very fine sandy loam
l=loam

Table 4 -- Soil moisture retention data for the major soils of Imperial Valley[1/]

Soil[2/]	Depth	Moisture content (dry weight basis) at specified suctions (bars)					
		0.1	0.3	1.0	2.0	5.0	15.0
	Inches	Percent	Percent	Percent	Percent	Percent	Percent
Imperial sic	0-13	41.1	32.9	26.4	26.0	20.7	18.6
	13-28	45.7	36.8	30.7	29.2	24.2	23.1
	28-42	46.2	37.7	30.9	29.1	24.7	22.8
Holtville sic	0-10	41.1	30.8	24.4	23.9	19.4	16.8
	10-22	41.4	33.3	27.6	26.5	22.6	19.4
	33-50	42.3	30.4	14.8	12.6	10.0	9.3
	50-66+	39.8	13.0	7.6	7.1	5.9	5.1
Holtville sic Taxadjunct	0-17	36.8	30.2	24.8	24.4	19.5	16.6
	17-24	43.9	34.5	29.6	28.0	23.1	20.2
	24-35	37.8	31.4	22.3	19.0	14.8	11.8
	35-72+	20.0	6.2	5.0	4.3	3.7	3.1
Meloland l	0-12	28.8	14.6	14.0	10.3	8.3	6.9
	12-18	20.4	6.7	5.2	5.0	4.2	3.8
	18-26	37.7	24.2	15.0	11.8	9.5	7.9
	26-38	45.8	37.6	31.2	30.3	24.5	21.9
	38-53	46.0	37.4	31.9	30.8	24.6	21.3
Indio l	0-12	30.2	19.6	13.0	12.8	10.3	8.3
	12-30	40.0	21.8	16.9	11.3	8.9	7.1
	44-58	37.6	10.6	10.7	6.4	5.3	4.7
Indio vfsl Taxadjunct	0-13	30.8	18.2	14.2	12.6	10.1	8.1
	13-27	32.8	14.8	10.6	8.7	7.1	5.8
	27-37	35.2	22.8	13.8	10.9	8.6	6.8
	37-62	9.0	5.3	4.3	3.5	3.1	2.4

1/ Determined on artifacts of crushed, sieved samples.
2/ sic=silty clay
vfsl=very fine sandy loam
l=loam

Table 5 -- The average bulk density and standard deviation (four replications) at field moisture conditions for the major Imperial Valley soils

Soil[1/]	Depth	Bulk density
	Inches	g/cm^3
Imperial sic	0-12	1.37 ± 0.12
	12-24	1.52 ± .03
	24-36	1.55 ± .06
	36-48	1.55 ± .08
	48-60	1.52 ± .02
	60-72	1.56 ± .03
Holtville sic	0-12	1.40 ± .06
	12-24	1.51 ± .01
	24-36	1.50 ± .01
	36-48	1.46 ± .02
	48-60	1.48 ± .03
	60-72	1.50 ± .07
Holtville sic Taxadjunct	0-6	1.10 ± .06
	6-12	1.43 ± .05
	12-18	1.50 ± .03
	18-24	1.50 ± .04
	24-30	1.56 ± .04
	30-36	1.66 ± .06
	36-42	1.61 ± .04
	42-48	1.60 ± .01
	48-54	1.66 ± .04
	54-60	1.69 ± .02
Meloland l	0-6	1.29 ± .16
	6-12	1.42 ± .08
	12-18	1.46 ± .04
	18-24	1.41 ± .06
	24-30	1.41 ± .09
	30-36	1.44 ± .03
	36-42	1.48 ± .03
	42-48	1.59 ± .02
	48-54	1.55 ± .05
	54-60	1.58 ± .05
Indio l	0-12	1.63 ± .06
	12-24	1.48 ± .03
	24-36	1.46 ± .03
	36-48	1.53 ± .02
	48-60	1.59 ± .06
	60-72	1.64 ± .04

See footnote at end of table

Table 5 -- continued

Soil[1/]	Depth	Bulk density
	Inches	g/cm^3
Indio vfsl Taxadjunct	0-6	1.39 ± .08
	6-12	1.49 ± .02
	12-18	1.52 ± .03
	18-24	1.58 ± .01
	24-30	1.60 ± .03
	30-36	1.66 ± .04
	36-42	1.67 ± .04
	42-48	1.74 ± .03
	48-54	1.70 ± .02
	54-60	1.68 ± .11

1/ sic = silty clay
vfsl = very fine sandy loam
l = loam

Table 6 -- The average infiltration rate (for an 8-hour period), standard deviation, and coefficient of variation (six replications) for the major Imperial Valley soils

Soil[1/]	Infiltration rate	Coefficient of variation
	In/hr	Percent
Imperial sic	0.051 ± 0.010	19.6
Holtville sic	.092 ± .039	42.4
Holtville sic Taxadjunct	.396 ± .318	80.3
Meloland l	.315 ± .083	26.3
Indio l	.208 ± .116	55.8
Indio vfsl Taxadjunct	.267 ± .163	60.9

1/ sic = silty clay
vfsl = very fine sandy loam
l = loam

Table 7 -- Saturation extract determinations

Soil[1/]	Depth	Electrical Conductivity	Cations					Anions					Sodium Adsorption Ratio (SAR)
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Total	$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$	Cl^{-}	Total	
	Inches	Mmhos/cm	Meq/l	Meq/l	Meq/l	Meq/l	Meq/l	Meq/l	Meq/l	Meq/l	Meq/l	Meq/l	
Imperial sic	0-13	4.9	22.90	11.87	24.0	0.76	59.53	0	8.56	38.52	19.26	66.34	5.8
	13-28	9.0	24.80	21.31	78.0	.40	124.51	0	2.97	104.10	24.01	131.08	16.2
	28-42	12.0	35.02	15.74	112.0	.70	163.46	0	2.90	83.28	67.86	154.04	22.2
Holtville sic	0-10	6.8	30.50	19.64	38.0	1.70	89.84	0	6.53	58.30	26.10	90.93	7.6
	10-22	7.4	27.80	21.28	68.0	.90	117.98	0	3.63	80.68	23.49	107.80	13.7
	33-50	13.0	35.80	22.82	120.0	.56	179.18	0	4.21	74.95	82.48	161.64	22.2
	50-66+	9.2	30.60	19.01	48.0	.88	98.49	0	6.09	41.64	60.65	108.38	9.6
Holtville sic Taxadjunct	0-17	5.0	24.25	12.03	30.0	.96	67.24	0	7.54	48.41	16.96	72.91	7.0
	17-24	5.0	23.83	15.58	26.0	.72	66.13	0	5.51	60.38	9.92	75.81	5.9
	24-35	3.3	10.99	6.41	15.2	.48	33.08	0	5.08	28.11	12.27	45.46	5.2
	35-72+	4.8	12.00	7.50	28.8	.72	49.02	0	5.95	34.35	12.53	52.83	9.2
Meloland l	0-12	7.0	32.38	19.72	32.0	.56	84.66	0	3.77	52.57	29.49	85.83	6.3
	12-18	2.8	9.80	1.44	11.2	.26	22.70	0	8.85	14.57	8.35	31.77	4.7
	18-26	7.0	27.54	22.27	45.0	.28	95.09	0	2.90	87.44	21.92	112.26	9.0
	26-38	7.4	24.75	17.01	50.0	.40	92.16	0	6.53	94.73	13.05	114.31	10.9
	38-53	8.0	20.56	19.90	62.0	.54	103.00	0	5.80	99.42	15.66	120.88	13.8
Indio l	0-12	5.0	21.43	15.09	20.4	1.40	58.32	0	8.70	33.31	21.14	63.15	4.8
	12-30	7.0	31.92	19.99	34.8	.89	87.60	0	4.21	64.54	33.15	101.90	6.8
	44-58	5.6	23.60	11.80	24.8	1.40	61.60	0	8.56	32.27	21.92	62.75	5.9
Indio sic Taxadjunct	0-13	19.0	26.85	27.96	148.0	1.28	204.09	0	9.43	122.84	83.52	215.79	28.3
	13-27	17.0	27.35	28.16	152.0	.46	207.97	0	7.91	116.59	91.35	215.85	28.8
	27-37	12.0	20.56	15.81	122.0	.46	158.83	0	8.12	122.84	36.02	166.98	28.6
	37-62	13.0	10.94	16.78	126.0	.30	154.02	0	14.51	68.70	64.63	147.84	33.8

1/ sic = silty clay
l = loam

Table 8 -- Soil determinations

Soil [1]	Depth	Saturation	pH of saturated soil	Cation exchange capacity	Exchangeable cation percentages		Gypsum	Calcium carbonate equivalent	Free iron oxides	Total surface area
					Na^+	K^+		$\%CaCO_3$	$\%Fe_2O_3$	
	Inches	Percent		Meq/100g			Meq/100g			M^2/g
Imperial sic	0-13	76.9	7.6	34.2	14	4	1.2	12.39	1.18	204.82
	13-28	77.2	7.9	32.0	22	2	7.3	14.34	1.36	194.75
	28-42	76.2	7.9	33.8	15	3	2.2	14.32	1.30	195.01
Holtville sic	0-10	66.5	7.6	27.5	12	5	2.6	11.77	1.14	172.28
	10-22	77.8	7.7	30.5	9	3	5.4	11.38	1.12	202.47
	33-50	42.1	7.7	16.0	11	3	2.2	16.69	.84	102.75
	50-66+	21.6	7.7	10.2	17	4	.2	14.08	.69	61.42
Holtville sic Taxadjunct	0-17	70.0	7.7	29.5	21	4	.6	12.42	1.04	172.78
	17-24	83.0	7.7	34.8	17	3	1.4	12.18	1.01	216.42
	24-35	54.7	7.8	24.2	27	3	.4	14.82	.84	140.84
	35-72+	17.2	7.7	7.4	30	5	.0	7.90	.46	36.42
Meloland l	0-12	40.5	7.6	13.2	15	3	.4	9.55	.64	65.24
	12-18	20.6	7.6	7.2	19	3	.1	8.74	.44	38.66
	18-26	41.2	7.6	15.6	19	2	1.8	15.63	.72	90.23
	26-38	93.2	7.7	38.0	16	2	5.6	12.13	1.09	216.08
	38-53	88.1	7.9	35.2	18	2	5.7	13.08	1.15	214.10
Indio l	0-12	35.5	7.6	15.5	30	6	.2	11.14	.73	90.15
	12-30	39.9	7.7	15.0	11	3	.4	14.88	.86	78.80
	44-58	19.8	7.9	9.8	19	3	.2	13.82	.56	54.39
Indio sic Taxadjunct	0-13	43.1	7.9	14.4	26	4	5.5	11.56	.64	82.88
	13-27	38.0	8.2	12.0	20	5	5.6	12.20	.60	66.36
	27-37	44.3	8.1	14.6	16	4	1.9	13.98	.68	81.31
	37-62	13.2	8.2	6.5	23	3	.0	6.39	.40	26.24

[1] sic = silty clay
l = loam

Table 9 -- Organic nitrogen, organic carbon and organic matter

Soil[1]	Depth	Organic nitrogen[2]	Organic carbon[3]	Organic matter[4]
	Inches	P/m	Percent	Percent
Imperial sic	0-13	784	0.69	1.19
	13-28	378	.30	.52
	28-42	374	.28	.49
Holtville sic	0-10	746	.82	1.41
	10-22	488	.43	.74
	35-50	232	.30	.51
	50-66+	126	.14	.24
Holtville sic Taxadjunct	0-17	558	.52	.90
	17-24	318	.22	.38
	24-35	238	.20	.34
	35-72+	52	.05	.08
Meloland l	0-12	476	.42	.73
	12-17	91	.08	.13
	17-26	231	.23	.40
	26-38	354	.26	.44
	38-53	374	.26	.44
Indio l	0-12	498	.48	.82
	12-30	310	.44	.76
	44-58	110	.12	.20
Indio vfsl Taxadjunct	0-13	354	.31	.54
	13-27	134	.11	.19
	27-37	136	.13	.22
	37-62	32	.03	.06

1/ sic = silty clay
vfsl = very fine sandy loam
l = loam

2/ Kjeldahl method.

3/ Calculated from organic matter: Organic carbon = percentage of organic matter/1.72.

4/ Walkley-Black method: Percentage of organic matter = (meq $K_2Cr_2O_7$) (0.69)/g soil.

Table 10 -- Phosphorus Analysis of Soils

Soil[1/]	Depth	Total-P (mineral and organic)	Phosphorus fractionation analysis					0.5N $NaHCO_3$ extractable-P
			Organic-P	Aluminum-P	Iron-P	Calcium-P	Other-P	
	Inches	P/m	P/m	P/m	P/m	P/m	P/m	P/m
Imperial sic	0-13	875	33	64	1	610	167	20
	13-28	760	8	18	1	574	159	4
	28-42	772	20	20	1	590	141	9
Holtville sic	0-10	818	45	59	2	497	215	16
	10-22	712	20	23	1	497	171	4
	33-50	712	0	11	1	573	127	6
	50-66+	625	42	10	1	542	30	4
Holtville sic	0-17	835	8	51	0	527	249	15
Taxadjunct	17-24	742	20	27	0	497	198	3
	24-35	733	8	15	0	454	256	1
	35-72+	438	8	11	0	250	169	3
Meloland l	0-12	612	43	59	1	401	108	11
	12-18	524	29	8	2	376	109	10
	18-26	673	8	11	0	454	200	2
	26-38	732	45	18	0	401	268	3
	38-53	781	68	20	0	590	103	6
Indio l	0-12	712	32	69	2	512	97	30
	12-30	692	20	13	1	527	131	5
	44-58	594	19	11	1	441	122	3
Indio vfsl	0-13	712	32	34	0	512	134	18
Taxadjunct	13-27	675	0	11	0	497	167	1
	27-37	663	20	11	0	558	74	2
	37-62	356	46	11	0	282	17	2

1/ sic = silty clay
vfsl = very fine sandy loam
l = loam

Table 11 -- Linear regression analysis of clay content (<2μ) as related to a given soil property

Soil Property	Slope	Intercept	Correlation coefficient	Significance level 1/
Physical measurements				
Moisture retention (bars):				
0.1	0.3339	27.2383	0.682	S **
.3	.5044	10.5520	.885	S **
1.0	.4627	6.1857	.957	S **
2.0	.4871	3.7812	.982	S **
5.0	.4004	2.9593	.982	S **
15.0	.3450	2.4020	.993	S **
Soil bulk density (g/cm^3)	------	-------	- .384	NS
Atterburg constants:				
Liquid limit (percent)	.7881	18.8934	.984	S **
Plastic limit (percent)	------	-------	- .205	NS
Plastic index (No.)	.8066	- 3.6802	.989	S **
Optimum moisture content (percent)	------	-------	.261	NS
Maximum density (lb/ft^3)	------	-------	- .029	NS
Chemical measurements				
Saturation extract determinations:				
Electrical conductivity (mmhos/cm)	------	-------	- .227	NS
Total cations (meq/l)	------	-------	- .113	NS
Total anions (meq/l)	------	-------	- .099	NS
Sodium adsorption ratio	------	-------	- .220	NS
Soil determinations:				
Saturation (percent)	1.2530	18.0602	0.969	S **
Cation exchange capacity (meq/100g)	.5460	6.2440	.984	S **
Exchangeable sodium (percent)	------	-------	- .324	NS
Exchangeable potassium (percent)	------	-------	- .266	NS
Gypsum (meq/100 g)	.0586	.6557	.480	S *
Calcium carbonate equivalent (percent $CaCO_3$)	------	-------	.178	NS
Free iron oxides (percent Fe_2O_3)	.0134	.4924	.908	S **
Total surface area (m^2/g)	3.4573	30.1160	.986	S **
Organic matter determinations:				
Organic matter (percent)	.0097	.2537	.539	S **
Organic nitrogen (p/m)	7.5022	121.0291	.704	S **
Phosphorous analysis:				
Extractable-P (p/m)	------	-------	.160	NS
Total-P (p/m)	4.6842	560.2998	.748	S **

1/ Significance level with 23 samples each.

S = significant correlation.
* = 5-percent level.
** = 1-percent level.
NS = nonsignificant correlation

Table 12 -- Linear regression analysis of soil saturation percentage as related to given soil property

Soil property	Slope	Intercept	Correlation coefficient	Significance level 1/
Physical measurements				
Moisture retention (bars):				
0.1	0.2860	21.4250	0.756	S **
.3	.4143	2.6811	.940	S **
1.0	.3664	- .3348	.980	S **
2.0	.3774	- 2.6589	.984	S **
5.0	.3085	- 2.2436	.978	S **
15.0	.2937	- 2.0017	.987	S **
Soil bulk density (g/cm^3)	------	-------	- .401	NS
Atterburg constants:				
Liquid limit (percent)	.5926	9.4019	.957	S **
Plastic limit (percent)	------	-------	- .240	NS
Plastic index (No.)	.6083	-13.4855	.965	S **
Optimum moisture content (percent)	------	-------	.386	NS
Maximum density (lb/ft^3)	------	-------	- .070	NS
Chemical measurements				
Saturation extract determinations:				
Electrical conductivity (mmhos/cm)	------	-------	- .114	NS
Total cations (meq/l)	------	-------	.012	NS
Total anions (meq/l)	------	-------	.043	NS
Sodium adsorption ratio	------	-------	- .129	NS
Soil determinations:				
Cation exchange capacity (meq/100 g)	0.4220	-0.9218	0.984	S **
Exchangeable sodium (percent)	------	------	- .365	NS
Exchangeable potassium (percent)	------	------	- .348	NS
Gypsum (meq/100 g)	.0551	- .6164	.583	S **
Calcium carbonate equivalent (percent $CaCO_3$)	------	------	.309	NS
Free iron oxides (percent Fe_2O_3)	.0104	.3149	.912	S **
Total surface area (m^2/g)	2.6574	-14.4842	.980	S **
Organic matter determinations:				
Organic matter (percent)	.0068	.1590	.493	S *
Organic nitrogen (p/m)	5.3865	43.7488	.654	S **
Phosphorous analysis:				
Extractable-P (p/m)	------	------	.076	NS
Total-P (p/m)	3.8288	488.1472	.791	S **

1/ Significance level with 23 samples each.

S = significant correlation
* = 5-percent level
** = 1-percent level
NS = nonsignificant correlation

Table 13 -- Linear regression analysis of the sodium adsorption ratio as related to exchangeable sodium percentage and pH

Soil property	Slope	Intercept	Correlation coefficient	Significance level 1/
Exchangeable sodium (percent) (ESP)	-----	-------	0.021	NS
pH	0.0167	7.5576	.820	S **

1/ Significance level with 23 samples each.

NS = nonsignificant correlation
S = significant correlation
** = 1-percent level

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